Mechanics of Digital Lattice Materials for Re-configurable Space Structures

Completed Technology Project (2016 - 2018)

Project Introduction

Because of the challenges associated with the inability to resupply for repair, future deep space exploration missions will require innovative material and structural solutions to achieve lighter, stronger, more reliable, and more multifunctional structures. Digital lattice materials offer a unique approach to achieving these goals, generating from discrete parts lattice solids that behave as continuum materials. Such materials have shown extraordinary strength and stiffness properties at ultralow density, are reconfigurable, and allow customization of material properties based on control of lattice substructure. Despite demonstration of these properties, the failure mechanisms, fracture toughness, and fatigue properties of these materials are not well understood. Characterization of these properties is critical for safe and efficient implementation of these materials in critical load bearing applications. This project seeks to not only characterize the fundamental fracture and fatigue scaling laws associated with digital lattice materials of cuboctahedral structure, but also investigate novel macrostructural toughening mechanisms. In additional, because the potential for reconfigurablity is a primary advantage of these materials in deep space (where material lifecycle is of critical importance), this research will also investigate appropriate characterization of material fracture and fatigue properties for reconfigured digital lattice structures. Experimental investigation will utilize standard fatigue and fracture specimens (3 point bend notched specimen) to compare the behavior of digital lattice materials to other cellular solids. These will also be compared to similar tests that investigate the influence of macroscopic toughening features designed into the lattice on fracture and fatigue performance. Finally, similar tests will be used to verify the ability to predict degraded fracture and fatigue properties associated with reconfigured material that has be pre-cycled. The results of this work will be in direct support of NASA Technological Roadmap Technology Area 12 by investigating novel approaches to increasing the toughness (and therefore reliability) of ultra-lightweight structures. Such work is also critical for designing appropriate health monitoring strategies. Finally, ability to predict the degraded properties of reconfigured material is a key enabling technology material recylcability that could revolutionize material and structural life cycles in space applications.

Anticipated Benefits

The results of this work will be in direct support of NASA Technological Roadmap Technology Area 12 by investigating novel approaches to increasing the toughness (and therefore reliability) of ultra-lightweight structures. Such work is also critical for designing appropriate health monitoring strategies. Finally, ability to predict the degraded properties of reconfigured material is a key enabling technology material recyclability that could revolutionize material and structural life cycles in space applications.

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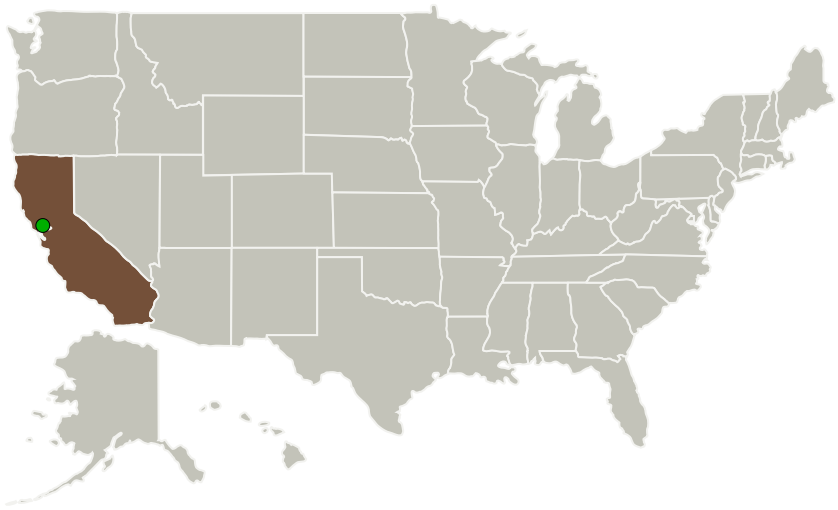
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
University of California-Berkeley(Berkeley)	Lead Organization	Academia	Berkeley, California
Ames Research Center(ARC)	Supporting Organization	NASA Center	Moffett Field, California

Primary U.S. Work Locations
California

Project Website:

https://www.nasa.gov/strg#.VQb6T0jJzyE

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

University of California-Berkeley (Berkeley)

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

Lisa Pruitt

Co-Investigator:

Christine E Gregg

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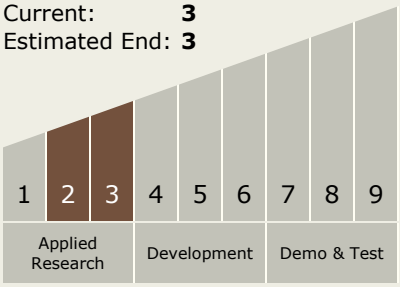
Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
  - TX12.1 Materials
    - TX12.1.1 Lightweight Structural Materials

Target Destinations

Earth, The Moon, Mars